MANITOBA CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

WASTE HEAT RECOVERY

ELM CREEK CURLING CLUB

ELM CREEK, MANITOBA

Canada

MANITOBA

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CONSERVATION AND RENEWABLE ENERGY BRANCH
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The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

EXECUTIVE SUMMARY

The Elm Creek Curling Club received funding under the Manitoba/Canada Conservation and Renewable Energy Demonstration Agreement (CREDA), to assist in the construction of an energy conserving heating system for the town's curling rink and skating arena complex.

The volunteer-built system recovers waste heat produced by the artificial ice plant and distributes it via hot water for space heating of the curling rink lobby, playing areas and the waiting and dressing rooms of the natural ice hockey arena.

In conventional ice plant operations, the heat extracted from the ice surface is exhausted outdoors.

By recovering this heat the Elm Creek Curling Club has eliminated the need for any other heating fuel. Based on comparison with other arena complexes, simple payback within three years is possible.

Some problems were encountered with the system as originally designed and built. During warmer periods, more heat was recovered than could be distributed or stored. The original design has been altered so that this excess heat is now dumped through a bypass line, to an outdoor cooler.

Water leakage from the system storage cisterns was the other major problem; a result of faulty construction. This has now been repaired.

Operating experience since has been quite satisfactory.

This report describes the design and operating experience at Elm Creek and recommends improvements, as a guide for others considering the incorporation of similar systems at other facilities. The importance of proper engineering design and construction is stressed.

RÉSUME ADMINISTRATIF

Le club de curling d'Elm Creek a reçu des fonds au titre de l'Entente Canada - Manitoba de démonstration des énergies renouvelables et des économies d'énergie (ECMDEREE) afin de construire un système de chauffage à faible consommation énergétique pour l'ensemble piste de curling- patinoire de la petite ville.

Construit par des bénévoles, ce système récupère la chaleur perdue par la fabrique de glace artificielle et l'utilise pour produire de l'eau chaude. Cela permet de réchauffer le vestibule et les zones de jeu de la piste de curling ainsi que la salle d'attente et les vestiaires de la piste de hockey en glace naturelle.

Dans la fabrication habituelle de la glace, la chaleur extraite de la surface de la glace s'échappe à l'extérieur.

La récupération de cette chaleur a permis au club de curling d'Elm Creek d'éliminer l'emploi d'autres combustibles. En se basant sur une comparaison avec d'autres établissements de ce genre, il serait possible de récupérer les dépenses encourues en trois ans.

Certains problèmes relatifs au plan et à la construction initiaux se sont posés. Au cours des périodes plus chaudes, on récupérait plus de chaleur qu'on ne pouvait utiliser ou emmagasiner. Le plan initial a été modifié de façon à ce que cet excédent de chaleur soit maintenant évacué par des tuyaux de dérivation jusqu'à un système de refroidissement extérieur.

Par suite d'un défaut de construction, une fuite d'eau du système de réservoirs d'emmagasinage avait créé un autre problème important. Maintenant cela est réparé.

Depuis lors on est satisfait du fonctionnement.

Dans ce rapport, on fait une description des plans et du fonctionnement du complexe d'Elm Creek et on recommande des améliorations afin de servir de guide à ceux qui envisageraient l'incorporation de systèmes semblables dans d'autres établissements. On fait ressortir l'importance que prennent les plans techniques appropriés et la construction.

I. INTRODUCTION

Rising fuel costs have made the operation of ice rinks and arenas very expensive. With little hope of future improvement in this situation, operators are examining various means of incorporating energy conserving features into existing facilities and into the designs of new facilities.

This document reports on a specific technology of conservation, for facilities with artificial ice plants: heat recovery from the ice plant for space heating purposes. This is potentially one of the most economical means of reducing fuel related operating costs.

Essentially the recovery system takes the heat extracted from the ice and distributes it via hot water into the various occupied areas of the buildings. Standard practice at artificial ice facilities has been to dump thisheat outdoors via air blast coolers.

Heat saved in this manner displaces heat that is conventionally produced by oil or gas burning or by electrical resistance heating.

The heart of the recovery system is the ice plant compressor. The compressor acts as a heat pump, yielding high grade heat from the energy extracted from the ice; this heat is then transferred to circulating water by use of a heat exchanger.

Elm Creek Curling Club largely designed, funded and built this system with the help of community volunteers. Funding assistance of $11,800 was contributed by the Manitoba Department of Energy and Mines and by Energy, Mines and Resources Canada under the terms of the Manitoba/ Canada Conservation and Renewable Energy Demonstration Agreement (CREDA).

II. LOCATION

The Elm Creek Curling Club facilities are located in the Town of Elm Creek, Manitoba. Elm Creek is located at the intersection of Highways 2 and 13, about 60 km west south west of Winnipeg.

III. BUILDING DESCRIPTION

The Elm Creek sports facilities are housed in two buildings, separated by about 45 m. One is an older, natural ice hockey arena, and the other a new four sheet curling rink, which incorporates the majority of energy conserving features. (Figure A1).

The new structure is a steel building, 18.3 m wide, 4.3 m to the eaves and 57.9 m long, of which 45.7 m is the ice length. The roof has R18 foam insulation. The ice area walls are insulated to R12 with 4" fiberglass batt, and the reception area exterior walls are R18 (6" fiberglass).

The ice plant is located in a 3 meter high basement, beneath the reception area.

IV. ICE-MAKING SYSTEM

The system utilizes a Carrier Model 5H40 Freon* compressor unit, driven by a 23.4 kW (30 HP) electric motor. The plant is rated to extract 329 MJ (312,000 BTU) per hour of running time.

The ice is refrigerated by circulating brine, which is chilled by heat exchange in a Freon evaporator. The compressor pumped Freon is in turn cooled by heat transfer to circulating water, as part of the recovery system described below.

* Freon is a Dupont trademark for a class of refrigerant compounds.

V. HEAT RECOVERY AND DISTRIBUTION SYSTEM

5.1 General

The Elm Creek heat recovery and distribution system is illustrated in schematic Figure 1.

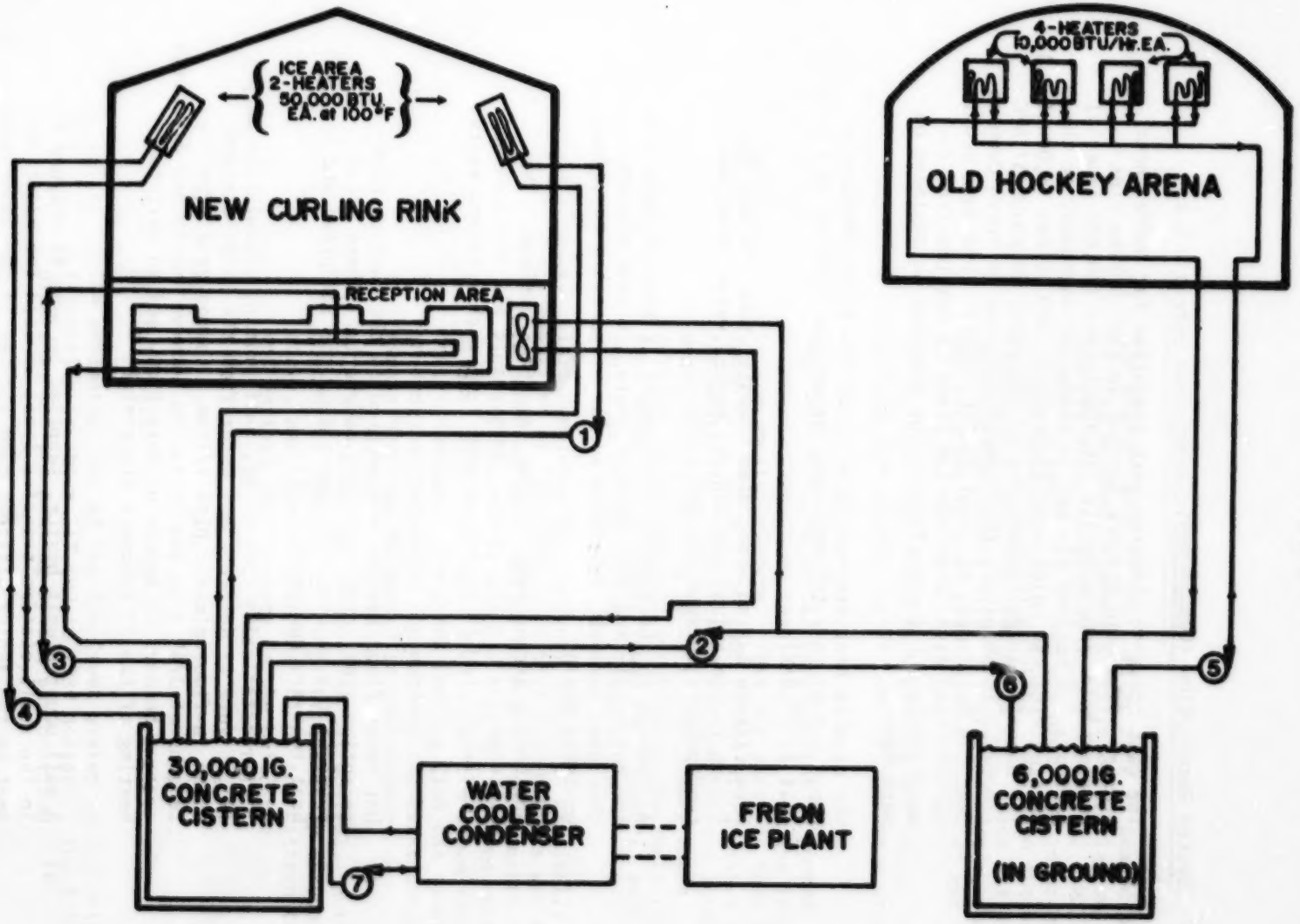
The purpose of this system is to use the heat extracted at the curling ice level to advantage, as the sole source of space heating for the two buildings. Standard practice at rinks with ice making equipment is to waste this heat to the atmosphere through air blast cooler (condensers) and to heat building areas with separate gas, oil or electric systems.

At Elm Creek, the chiller was bypassed, replaced by a system consisting of: water cooled condenser (Freon to water heat exchanger), water supply, pumps, hot water retention tanks, feed and return lines to infloor grids and various hot water unit heaters located in the two buildings.

In essence the unit heaters are performing the role of the air blast coolers, only the heat is released to the inside of the buildings. The rest of the reclamation system stores and distributes the heat to the heaters, when and where required.

5.2 System Description (Figure 1)

a) Hot Freon pumped by the compressor (Figure A2) is passed through the tube side of a Freon-to-water heat-exchanger (Figure A3), where it is cooled and returned to the brine-cooling section of the ice plant. Heat from the Freon passes to water circulated through the shell side of the exchanger. The water is pumped (pump #7) from a cistern (described below) by a 0.75 kW (1 HP) motor interlocked to start with the ice plant compressor. Town water makeup is fed into this line as required.



ELM CREEK, MAN.
FLOW DIAGRAM FOR
HOT WATER, HEAT RECOVERY SYSTEM

FIGURE 1

5.2 System Description (Continued)

b) The cast concrete cisterns were installed for buffer heat storage. The main cistern, located in the curling rink basement, holds approximately 136,400 litres (30,000 imperial gallons). A back-up cistern is installed inground, at the skating rink and holds approximately 27,300 litres (6,000 I.G.). The normal storage temperature of the water is about 37.8°C (100°F). If necessary this temperature can be drawn down to heat the buildings, to about 26.7°C (80°F). Drawdown occurs on very cold days, when the ice plant is not required for maintaining the ice surfaces. The drawdown is replaced on warm days.

The useable heat storage capacity of the large cistern is about 6.3 GJ (6×10^6 BTU) and the smaller cistern is 1.3 GJ (1.2×10^6 BTU).

Each cistern has an associated transfer pump (#2 and #6, Figure 1), to adjust and control manual water level and temperatures between the two tanks.

A drawback to the cistern arrangement is that in each case the hot supply and cool returns share the same cistern. They are, however, separated as far as possible to reduce unwanted mixing.

The hookup arrangement is also less than optimum. The cisterns use plastic liners; as a result all suctions and discharges had to be routed over top of the cistern walls.

c) Hot water floor heating was adopted in the curling rink reception area, club rooms and cafeteria. These areas surmount the machine room containing the ice plant and heat recovery equipment.

A thermostatically controlled, self-priming circulation pump (#3, Figure 1) delivers hot water from the large cistern to an in-floor plastic pipe system. Common grid pipe lengths of 3/4" pipe are installed between supply and discharge sparger headers to ensure uniform flow, and so uniform heating of the 3" concrete floor slab.

d) A wall mounted unit heater, supplied by pump #2 (Figure 1, in the small cistern transfer line) is used for additional heat to the senior citizens room located in the lobby area of the building.

5.2 System Description (Continued)

e) The playing area of the curling rink is heated by two ceiling mounted, thermostatically controlled unit fan heaters rated to deliver 50,000 BTU/hr (52.8 MJ/hr) at 37.8°C (Figure A4). They are oversized in order to provide adequate heating during times when the hot water temperature is drawn down to 26.7°C. Each has its own separate continuous water circulation system, fed from and returned to the large cistern (pumps #1 and 4, Figure 1).

Two in-wall reversible fans provide air change in the curling rink should excess humidity become a problem.

f) Heat not required in the curling rink is pumped (#2, Figure 1) through an insulated line from the large cistern to the smaller cistern. This hot water is then circulated (pump #5, Figure 1) to four 10,000 BTU/hr (10.6 MJ/hr) thermostatically controlled air fan heaters located in the dressing and waiting rooms in the hockey arena. The resulting cooled water is returned to the small cistern, from where it is pumped (pump #6, Figure 1) back to the cool side of the curling rink cistern.

g) This completes the recovery system as originally designed and installed at Elm Creek. In this design there was no provision for dumping heat that is excess to requirements of the facility, except by discharge of hot cistern water to sewer, in balance with town water cooling of the Freon through the heat exchanger. Elm Creek Curling Club has since installed an operable bypass to the outdoor air blast cooler so that excess heat can be dumped in this manner.

h) Most of the system is under manual control. Automatic control is limited to ice plant machinery (Freon pressure, etc.), and thermostatic control of the cistern temperature and various unit heaters in the buildings.

VI. COST ANALYSIS

6.1 Capital Costs

The estimated cost of the Elm Creek system in its original configuration is about $17,500 in 1980 dollars. The following breakdown for the heating system was provided.

6.1 Capital Costs (Continued)

Heat Exchanger	$ 3,000+
Cisterns (cement, lining and labour)	5,150
Piping in floor	321+
Pumps	914
Heaters - curling rink	1,187
- arena	1,000
Piping - curling rink	285
- arena	
. trenching	2,000
. pipe	514
. labour	300
Wiring (pumps, heaters, thermostats, etc.)	2,516
Miscellaneous (fittings, clamps, etc.)	360
Total	$ 17,547

+ Note that costs do not include the ice plant, or concrete for the waiting room floor which would be required regardless. An air blast chiller was included with the ice plant but was not used in the first year of operation.

Overall labour time was approximately 300 hours. Most of this was volunteer and therefore was not taken into account in the costing. If volunteer help were not available, labour could add a significant cost to the total.

6.2 Payback Period

To calculate a simple payback period, comparison is made to a similar size facility (four sheet curling rink and a hockey arena) located in the same general area as Elm Creek.

This facility spent approximately $7,000 to heat with gas in the 1981/82 season. Elm Creek would save all of this cost with incremental expense for electricity to run the pumps and for town water charges.

Total pump horsepower is 3½ HP. If run continuously these should consume only approximately $300 worth of electricity at 2.53¢/kW.h. Therefore total operating costs excluding maintenance should be less than $500 per operating season.

$$\text{Payback} = \frac{\$17,547}{\$7,000 \text{ (gas saving)} - \$500 \text{ (Operational Cost)}} = 2.7 \text{ years}$$

VII. OBSERVATIONS AND MONITORING

The Elm Creek system had some operational difficulties during the first year.

One significant problem has been discussed, that the compressors were able to supply more heat than was required for space heating the curling rink and arena. The rink operators found that at outdoor temperatures above 0°C, it was necessary to draw town water to cool the Freon, dumping the hot water to the sewer.

While use of town water was not of major concern at this location it could be in other regional communities. It should be noted again that Elm Creek has reincorporated their air blast cooler to dump excess heat and reduce water consumption during periods of excess heat production.

The other major problem encountered was cistern leaking. This was due to faulty construction and has been rectified by installation of a new bottom.

The other equipment performed satisfactorily. For example, the unit heaters in the curling rink were more than adequate in preventing condensation and fogging. No other direct source of heat was used or required, so a definite direct saving of energy resulted.

The total electrical bill (ie. the total energy bill) for all facility operations for the 1981/82 season was $3,800.

VIII. CONCLUSIONS AND RECOMMENDATIONS

1. The Elm Creek Curling Club rink heating system demonstrates a significant energy saving. It now performs essentially as the community volunteer group intended.

2. We would recommend that similar systems be installed in other facilities, providing proper engineering design and construction methods are followed.

3. Adequate provision should be made to economically handle any excess heat generated during the operation of the ice plant. Design for excess heat could take several forms, depending on the economics of the particular application.

   Possibilities include:

   a) incorporate bypass air blast cooler to dump excess heat

   b) size storage cisterns to retain excess heat

   c) distribute excess heat to off-site users/customers

VIII. Conclusions and Recommendations (Continued)

4. A brief engineering analysis of the Elm Creek heat recovery system suggested a number of improvements in the design. These were made after completion of the Elm Creek system and are meant to guide designers for other facilities considering this type of operation.

The suggested arrangement includes:

a) A compartmented main cistern with a hot side and cool side, to prevent mixing. Appropriate level controls for each side should be included.

b) One pump to pick up hot water from the heat exchanger, extracting water from the cistern cold side and discharging to the hot side.

c) One circulating pump for all space heating systems regardless of location, with temperatures, pressure and manual control as serves the needs of each circulating system.

d) One pump to extract water from the hockey arena cistern, to maintain the water level in that cistern.

The heat exchanger and circulating pumps should be the same, design permitting, so that one stand-by pump between them can serve as a spare for either. A valved suction manifold and valved discharger manifold would allow such a good maintenance arrangement.

e) The hockey arena cistern is not divided as the supply of hot water goes direct to the space heaters.

f) High points in all space heating circuits incorporate vacuum breaker/air vents to ensure the circulating circuits are not subjected to air locks.

g) The water heat exchanger is paralleled by a blast cooler to ensure heat, useable or waste, is properly handled according to need.

Again it must be stressed that these are guidelines, which may not be entirely appropriate to any other facility. Actual design would depend on specific conditions, subject to engineering recommendations.

APPENDIX A

PHOTOGRAPHS

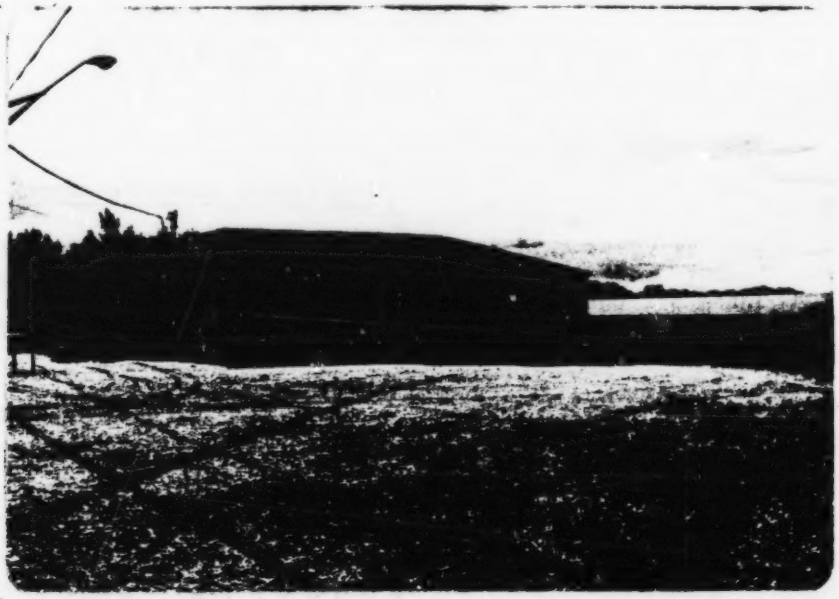


FIGURE A1
ELM CREEK CURLING CLUB COMPLEX -
CURLING RINK (FOREGROUND) & HOCKEY ARENA

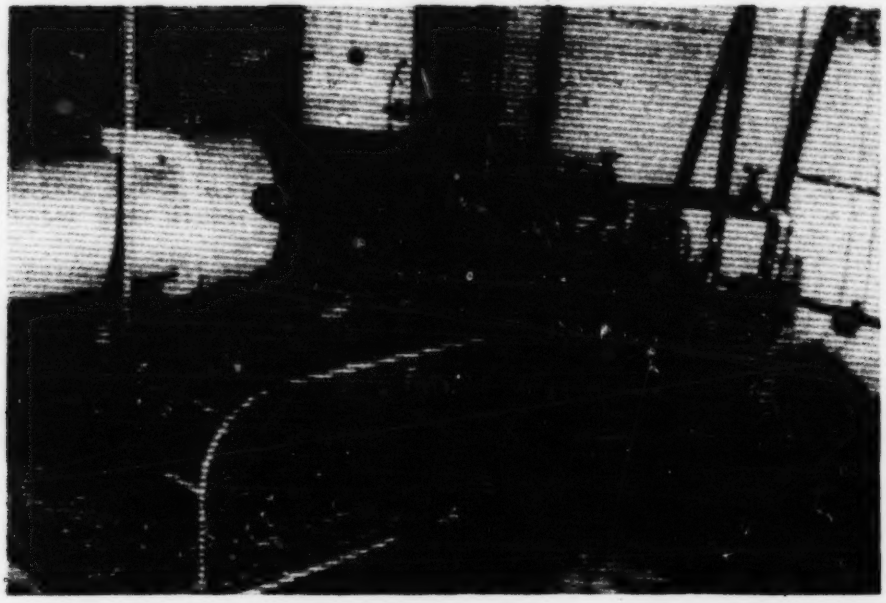


FIGURE A2
ICE PLANT COMPRESSOR (FOREGROUND)
HOT WATER CIRCULATING PUMPS (BACKGROUND)

FIGURE A3

FREON-TO-WATER HEAT EXCHANGER

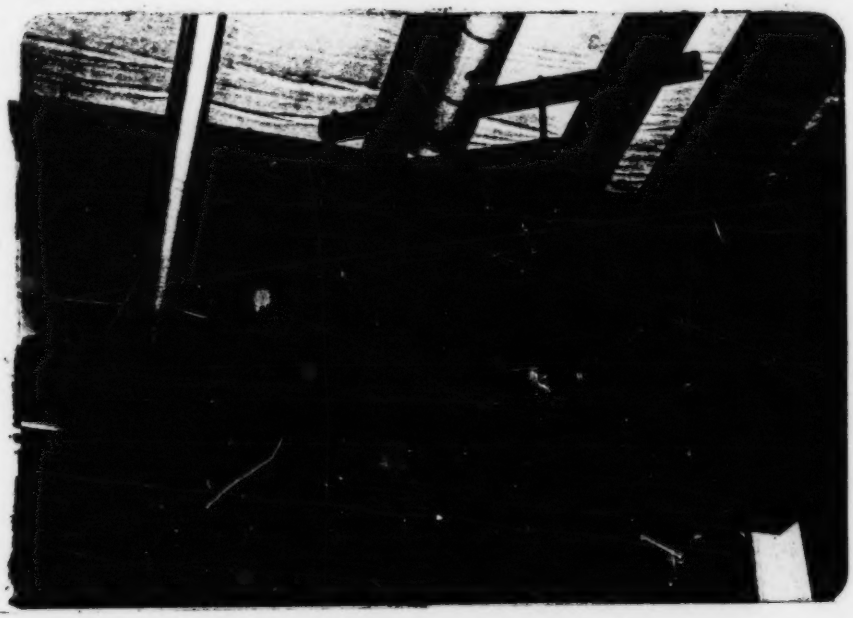


FIGURE A4
HOT WATER UNIT HEATER,
CURLING RINK PLAYING AREA

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